(0.03 in. $H_2O$), whichever is less restrictive. If this specification is met, the test data collected during the field test are valid. If the specification is not met, all test data collected since the last successful calibration or calibration check are invalid and shall be repeated using a pressure-measuring device with a current, valid calibration. Any device that fails the calibration check shall not be used in a field test until a successful recalibration is performed according to the procedures in section 10.3.3.

10.9 Temperature Gauges. Same as Method 2, section 4.3. The alternative thermocouple calibration procedures outlined in Emission Measurement Center (EMC) Approved Alternative Method (ALT–011) ''Alternative Method 2 Thermocouple Calibration Procedure'' may be performed. Temperature gauges shall be calibrated no more than 30 days prior to the start of a field test or series of field tests and recalibrated no more than 30 days after completion of a field test or series of field tests.

10.10 Barometer. Same as Method 2, section 4.4. The barometer shall be calibrated no more than 30 days prior to the start of a field test or series of field tests.

*11.0 Analytical Procedure*

Sample collection and analysis are concurrent for this method (see section 8.0).

*12.0 Data Analysis and Calculations*

These calculations use the measured yaw angle and the differential pressure and temperature measurements at individual traverse points to derive the near-axial flue gas velocity ($v_{a(i)}$) at each of those points. The near-axial velocity values at all traverse points that comprise a full stack or duct traverse are then averaged to obtain the average near-axial stack or duct gas velocity ($v_{a(avg)}$).

12.1 Nomenclature

A = Cross-sectional area of stack or duct at the test port location, $m^2$ ($ft^2$).

$B_{ws}$ = Water vapor in the gas stream (from Method 4 or alternative), proportion by volume.

$C_p$ = Pitot tube calibration coefficient, dimensionless.

$F_{2(i)}$ = 3-D probe velocity coefficient at 0 pitch, applicable at traverse point i.

$K_p$ = Pitot tube constant,

$$34.97\frac{\text{m}}{\text{sec}}\left[\frac{(\text{g/g-mole})(\text{mm Hg})}{(^\circ\text{K})(\text{mm H}_2\text{O})}\right]^{1/2}$$

for the metric system, and

$$85.49\frac{\text{ft}}{\text{sec}}\left[\frac{(\text{lb/lb-mole})(\text{in. Hg})}{(^\circ\text{R})(\text{in. H}_2\text{O})}\right]^{1/2}$$

for the English system.

$M_d$ = Molecular weight of stack or duct gas, dry basis (see section 8.13), g/g-mole (lb/lb-mole).

$M_s$ = Molecular weight of stack or duct gas, wet basis, g/g-mole (lb/lb-mole).

$$M_s = M_d(1 - B_{ws}) + 18.0B_{ws} \quad \text{Eq. 2G-2}$$

$P_{bar}$ = Barometric pressure at velocity measurement site, mm Hg (in. Hg).

$P_g$ = Stack or duct static pressure, mm $H_2O$ (in. $H_2O$).

$P_s$ = Absolute stack or duct pressure, mm Hg (in. Hg),

$$P_s = P_{bar} + \frac{P_g}{13.6} \quad \text{Eq. 2G-3}$$

$P_{std}$ = Standard absolute pressure, 760 mm Hg (29.92 in. Hg).

13.6 = Conversion from mm $H_2O$ (in. $H_2O$) to mm Hg (in. Hg).

$Q_{sd}$ = Average dry-basis volumetric stack or duct gas flow rate corrected to standard conditions, dscm/hr (dscf/hr).

$Q_{sw}$ = Average wet-basis volumetric stack or duct gas flow rate corrected to standard conditions, wscm/hr (wscf/hr).

$t_{s(i)}$ = Stack or duct temperature, °C (°F), at traverse point i.

$T_{s(i)}$ = Absolute stack or duct temperature, °K (°R), at traverse point i.

$$T_{s(i)} = 273 + t_{s(i)} \quad \text{Eq. 2G-4}$$

for the metric system, and

$$T_{s(i)} = 460 + t_{s(i)} \quad \text{Eq. 2G-5}$$

for the English system.

$T_{s(avg)}$=Average absolute stack or duct gas temperature across all traverse points.

$T_{std}$=Standard absolute temperature, 293°K (528°R).

$v_{a(i)}$=Measured stack or duct gas impact velocity, m/sec (ft/sec), at traverse point i.

$v_{a(avg)}$=Average near-axial stack or duct gas velocity, m/sec (ft/sec) across all traverse points.

$\Delta P_i$=Velocity head (differential pressure) of stack or duct gas, mm $H_2O$ (in. $H_2O$), applicable at traverse point i.

($P_1$-$P_2$)=Velocity head (differential pressure) of stack or duct gas measured by a 3-D probe, mm $H_2O$ (in. $H_2O$), applicable at traverse point i.

3,600=Conversion factor, sec/hr.

18.0=Molecular weight of water, g/g-mole (lb/lb-mole).

$\theta_{y(i)}$=Yaw angle of the flow velocity vector, at traverse point i.

n=Number of traverse points.

12.2 Traverse Point Velocity Calculations. Perform the following calculations from the measurements obtained at each traverse point.

12.2.1 Selection of calibration coefficient. Select the calibration coefficient as described in section 10.6.1.

12.2.2 Near-axial traverse point velocity. When using a Type S probe, use the following equation to calculate the traverse point near-axial velocity ($v_{a(i)}$) from the differential pressure ($\Delta P_i$), yaw angle ($\theta_{y(i)}$), absolute stack or duct standard temperature ($T_{s(i)}$) measured at traverse point i, the absolute stack or duct pressure ($P_s$), and molecular weight ($M_s$).

$$v_{a(i)} = K_p C_p \sqrt{\frac{(\Delta P)_i T_{s(i)}}{P_s M_s}} \left(\cos\theta_{y(i)}\right) \qquad \text{Eq. 2G-6}$$

Use the following equation when using a 3–D probe.

$$v_{a(i)} = K_p F_2 \sqrt{\frac{(P_1 - P_2)_i T_{s(i)}}{P_s M_s}} \left(\cos\theta_{y(i)}\right) \qquad \text{Eq. 2G-7}$$

12.2.3 Handling multiple measurements at a traverse point. For pressure or temperature devices that take multiple measurements at a traverse point, the multiple measurements (or where applicable, their square roots) may first be averaged and the resulting average values used in the equations above. Alternatively, the individual measurements may be used in the equations above and the resulting calculated values may then be averaged to obtain a single traverse point value. With either approach, all of the individual measurements recorded at a traverse point must be used in calculating the applicable traverse point value.

12.3 Average Near-Axial Velocity in Stack or Duct. Use the reported traverse point near-axial velocity in the following equation.

$$v_{a(avg)} = \frac{\sum_{i=1}^{n} v_{a(i)}}{n} \qquad \text{Eq. 2G-8}$$

12.4 Acceptability of Results. The acceptability provisions in section 12.4 of Method 2F apply to 3-D probes used under Method 2G. The following provisions apply to Type S probes. For Type S probes, the test results are acceptable and the calculated value of $v_{a(avg)}$ may be reported as the average near-axial velocity for the test run if the conditions in either section 12.4.1 or 12.4.2 are met.

12.4.1 The average calibration coefficient $C_p$ used in Equation 2G–6 was generated at nominal velocities of 18.3 and 27.4 m/sec (60 and 90 ft/sec) and the value of $v_{a(avg)}$ calculated using Equation 2G–8 is greater than or equal to 9.1 m/sec (30 ft/sec).

12.4.2 The average calibration coefficient $C_p$ used in Equation 2G–6 was generated at nominal velocities other than 18.3 or 27.4 m/sec (60 or 90 ft/sec) and the value of $v_{a(avg)}$ calculated using Equation 2G–8 is greater than or equal to the lower nominal velocity and less than or equal to the higher nominal velocity used to derive the average $C_p$.

12.4.3 If the conditions in neither section 12.4.1 nor section 12.4.2 are met, the test results obtained from Equation 2G–8 are not acceptable, and the steps in sections 12.2 and 12.3 must be repeated using an average calibration coefficient $C_p$ that satisfies the conditions in section 12.4.1 or 12.4.2.

12.5 Average Gas Volumetric Flow Rate in Stack or Duct (Wet Basis). Use the following equation to compute the average volumetric flow rate on a wet basis.

$$Q_{sw} = 3{,}600\left(v_{a(avg)}\right)(A)\left(\frac{T_{std}}{T_{s(avg)}}\right)\left(\frac{P_s}{P_{std}}\right) \qquad \text{Eq. 2G-9}$$

12.6 Average Gas Volumetric Flow Rate in Stack or Duct (Dry Basis). Use the following equation to compute the average volumetric flow rate on a dry basis.

$$Q_{sd} = 3{,}600\left(1 - B_{ws}\right)\left(v_{a(avg)}\right)(A)\left(\frac{T_{std}}{T_{s(avg)}}\right)\left(\frac{P_s}{P_{std}}\right) \qquad \text{Eq. 2G-10}$$

*13.0 Method Performance. [Reserved]*

*14.0 Pollution Prevention. [Reserved]*

*15.0 Waste Management. [Reserved]*

*16.0 Reporting.*

16.1 Field Test Reports. Field test reports shall be submitted to the Agency according to applicable regulatory requirements. Field test reports should, at a minimum, include the following elements.

16.1.1 Description of the source. This should include the name and location of the test site, descriptions of the process tested, a description of the combustion source, an accurate diagram of stack or duct cross-sectional area at the test site showing the dimensions of the stack or duct, the location of the test ports, and traverse point locations and identification numbers or codes. It should also include a description and diagram of the stack or duct layout, showing the distance of the test location from the nearest upstream and downstream disturbances and all structural elements (including breachings, baffles, fans, straighteners, etc.) affecting the flow pattern. If the source and test location descriptions have been previously submitted to the Agency in a document (e.g., a monitoring plan or test plan), referencing the document in lieu of including this information in the field test report is acceptable.

16.1.2 Field test procedures. These should include a description of test equipment and test procedures. Testing conventions, such as traverse point numbering and measurement sequence (e.g., sampling from center to wall, or wall to center), should be clearly stated. Test port identification and directional reference for each test port should be included on the appropriate field test data sheets.

16.1.3 Field test data.

16.1.3.1 Summary of results. This summary should include the dates and times of testing, and the average near-axial gas velocity and the average flue gas volumetric flow results for each run and tested condition.

16.1.3.2 Test data. The following values for each traverse point should be recorded and reported:

(a) Differential pressure at traverse point i ($\Delta P_i$)

(b) Stack or duct temperature at traverse point i ($t_{s(i)}$)

(c) Absolute stack or duct temperature at traverse point i ($T_{s(i)}$)

(d) Yaw angle at traverse point i ($\theta_{y(i)}$)

(e) Stack gas near-axial velocity at traverse point i ($v_{a(i)}$)

16.1.3.3 The following values should be reported once per run:

(a) Water vapor in the gas stream (from Method 4 or alternative), proportion by volume ($B_{ws}$), measured at the frequency specified in the applicable regulation

(b) Molecular weight of stack or duct gas, dry basis ($M_d$)

(c) Molecular weight of stack or duct gas, wet basis ($M_s$)

(d) Stack or duct static pressure ($P_g$)

(e) Absolute stack or duct pressure ($P_s$)

(f) Carbon dioxide concentration in the flue gas, dry basis ($\%_d\ CO_2$)

(g) Oxygen concentration in the flue gas, dry basis ($\%_d\ O_2$)

(h) Average near-axial stack or duct gas velocity ($v_{a(avg)}$) across all traverse points

(i) Gas volumetric flow rate corrected to standard conditions, dry or wet basis as required by the applicable regulation ($Q_{sd}$ or $Q_{sw}$)

16.1.3.4 The following should be reported once per complete set of test runs:

(a) Cross-sectional area of stack or duct at the test location (A)

(b) Pitot tube calibration coefficient ($C_p$)

(c) Measurement system response time (sec)

(d) Barometric pressure at measurement site ($P_{bar}$)

16.1.4 Calibration data. The field test report should include calibration data for all